ICF CONSULTING

CLIMATE CHANGE

International Vehicle Technology Symposium

Dr. Louis Browning

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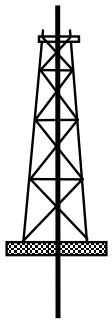
powered by perspective

Introduction

- Alternative fuels and advanced vehicle technologies offer substantial reductions in GHG emissions
- Fuel economy should be stated in miles per equivalent gasoline gallon (mpeg) for direct comparisons (energy basis)
- Comparison of alternative to conventional fuels should consider full fuel cycle emissions to take all factors into account

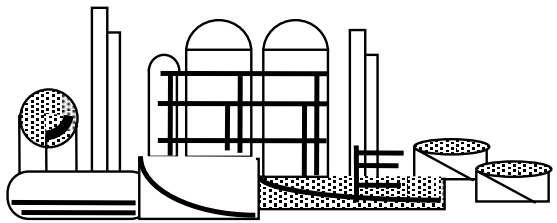
Full Fuel Cycle...

Emission impacts of alternative fuels should be compared on a full fuel cycle basis



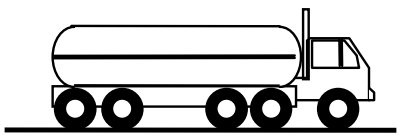
FEEDSTOCK EXTRACTION AND STORAGE

FEEDSTOCK TRANSPORTATION

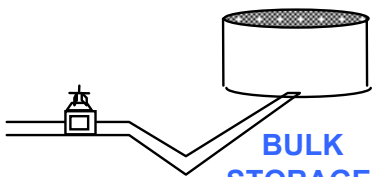


STORAGE AND FUEL PROCESSING

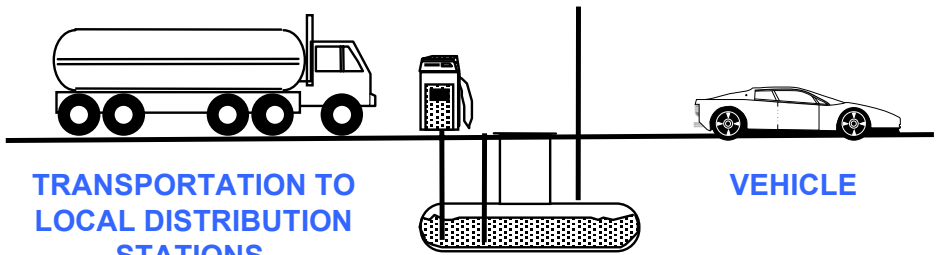
PROCESS STORAGE



TRANSPORTATION OF FUEL TO BULK STORAGE



BULK STORAGE

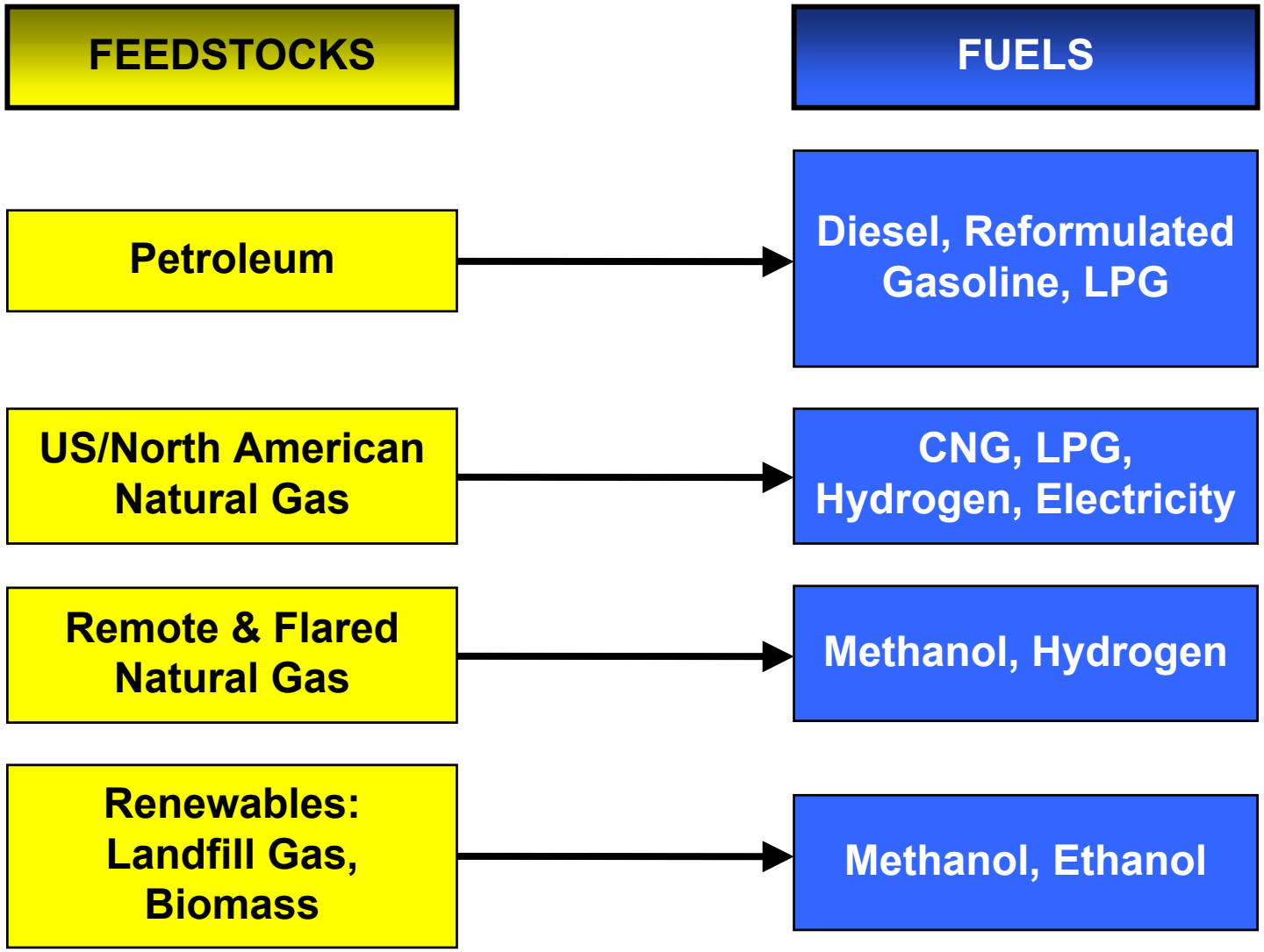


TRANSPORTATION TO LOCAL DISTRIBUTION STATIONS

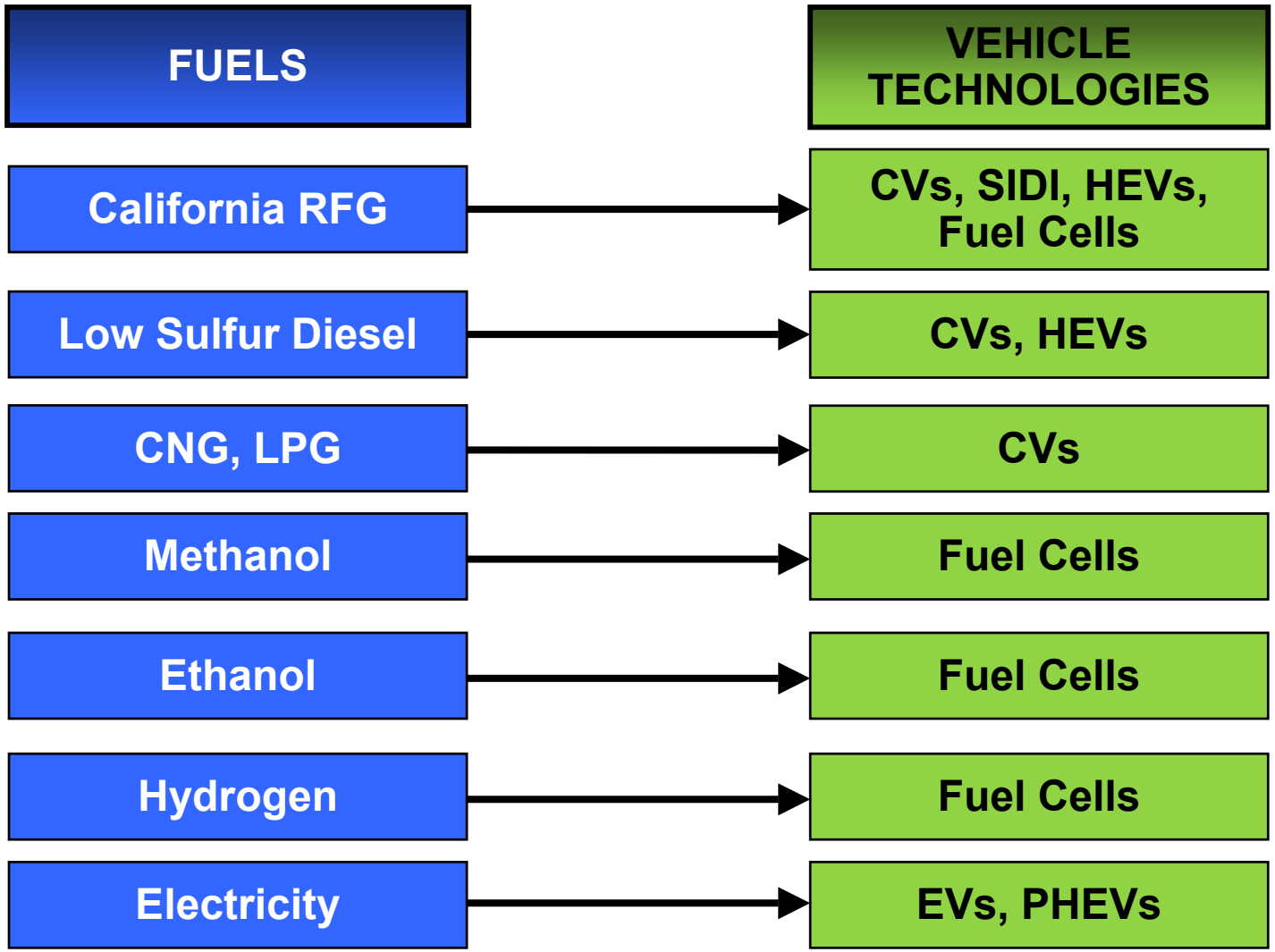
VEHICLE

LOCAL DISTRIBUTION STATIONS

Fuels and Feedstocks



Fuels and Vehicles



Model and Data Sources

- Modified version of ANL GREET 1.6
- California Specific baseline fuels
  - California RFG Phase 3
  - California Low Sulfur Diesel
- California Electricity Generation Mix
- GHG EFs from EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001
- Fuel economies from EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 and EPRI HEVWG reports

Scenarios

- New Mid-size Passenger Cars
- GHG Forming Potential
  - CO_2 = 1
  - CH_4 = 21
  - N_2O = 310
- Near Term – 2010
  - Fuels – CA RFG 3, CA LS Diesel, CNG, LPG, Electric
  - Vehicles - CVs, HEVs, PHEVs, EVs
  - Baseline – CV on CA RFG 3 – 25 mpg

Scenarios

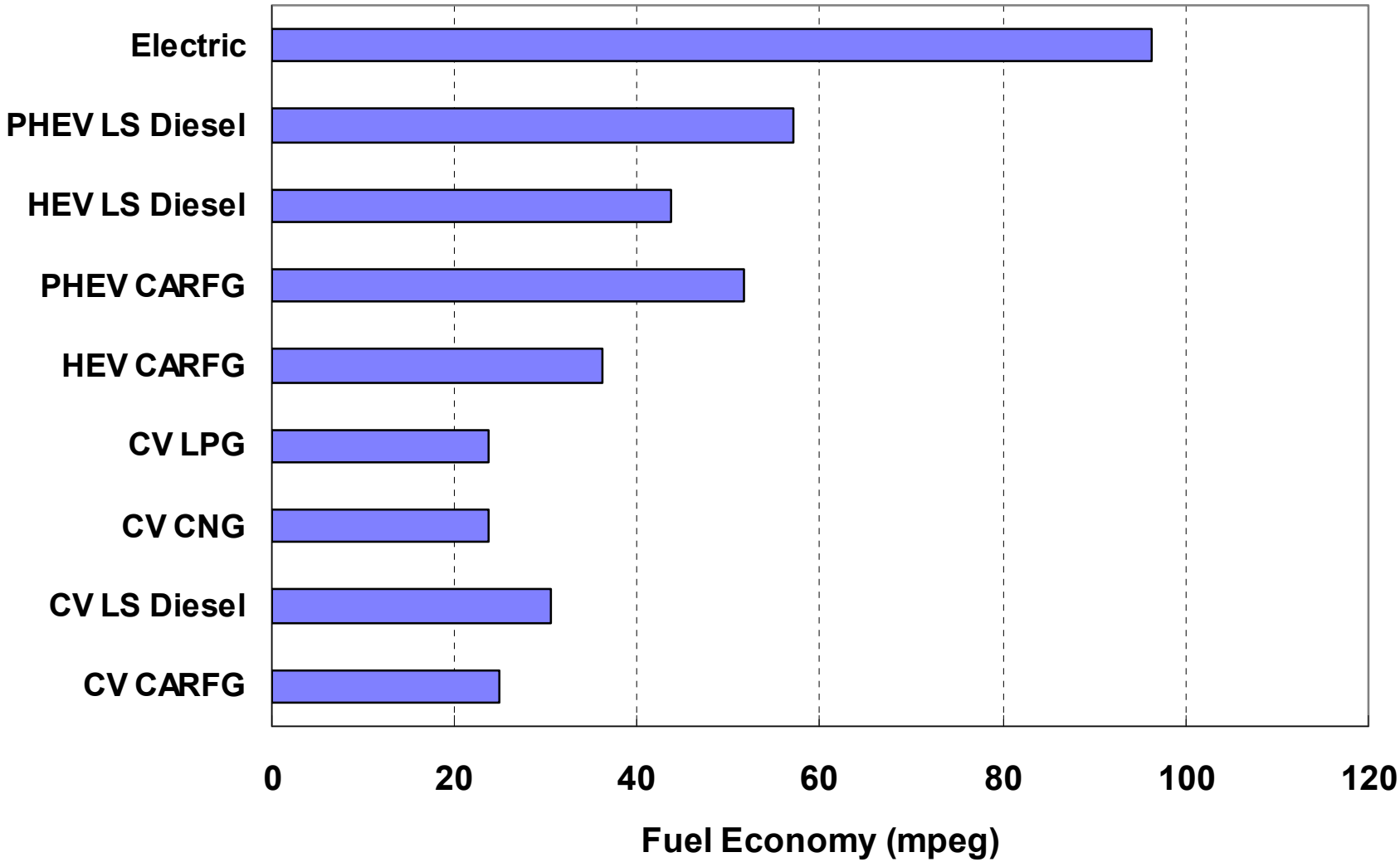
- Long Term – 2025
  - Fuels – CA RFG 3, CA LS Diesel, Methanol, Ethanol, Hydrogen, Electric
  - Hydrogen Production – Central Plant, Refueling Station, Electrolysis
  - Renewables – Flared Gas, Land Fill Gas, Biomass
  - Vehicles - CVs, SIDI, HEVs, PHEVs, FCV, EVs
  - Baseline – CV on CA RFG 3 – 29 mpg

California Electricity Generation Mix Projections

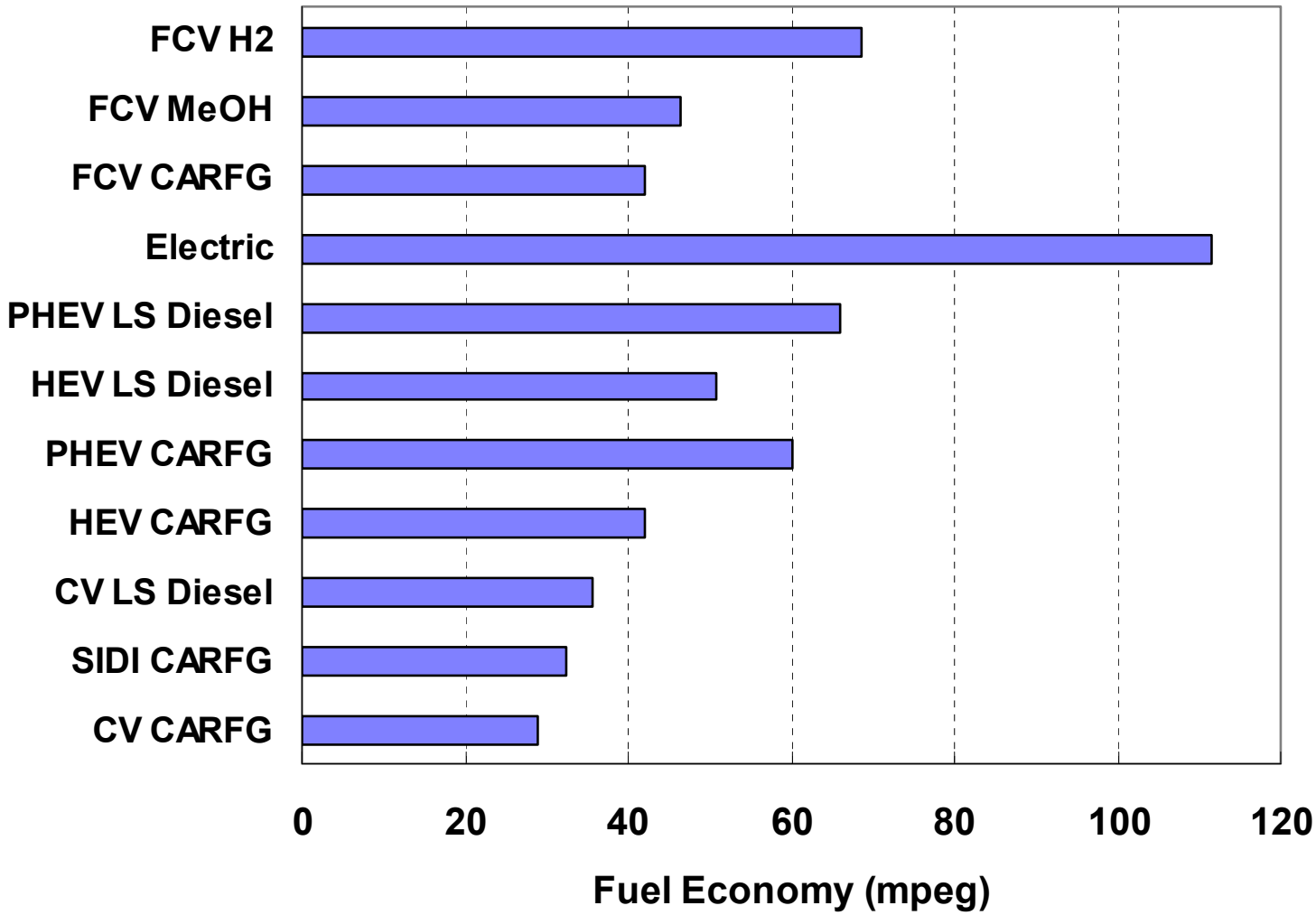
Determined using ICF Consulting's IPM Forecast Model
Average Generation mix assumed for fuel production & transportation use

Fuel	2010 Simulation	2025 Simulation
Residual oil	0.0%	0.0%
Natural gas	48.2%	67.1%
Coal	1.3%	0.8%
Nuclear	15.9%	10.0%
Others	34.6%	22.1%
CC NG / NG	71.9%	88.0%

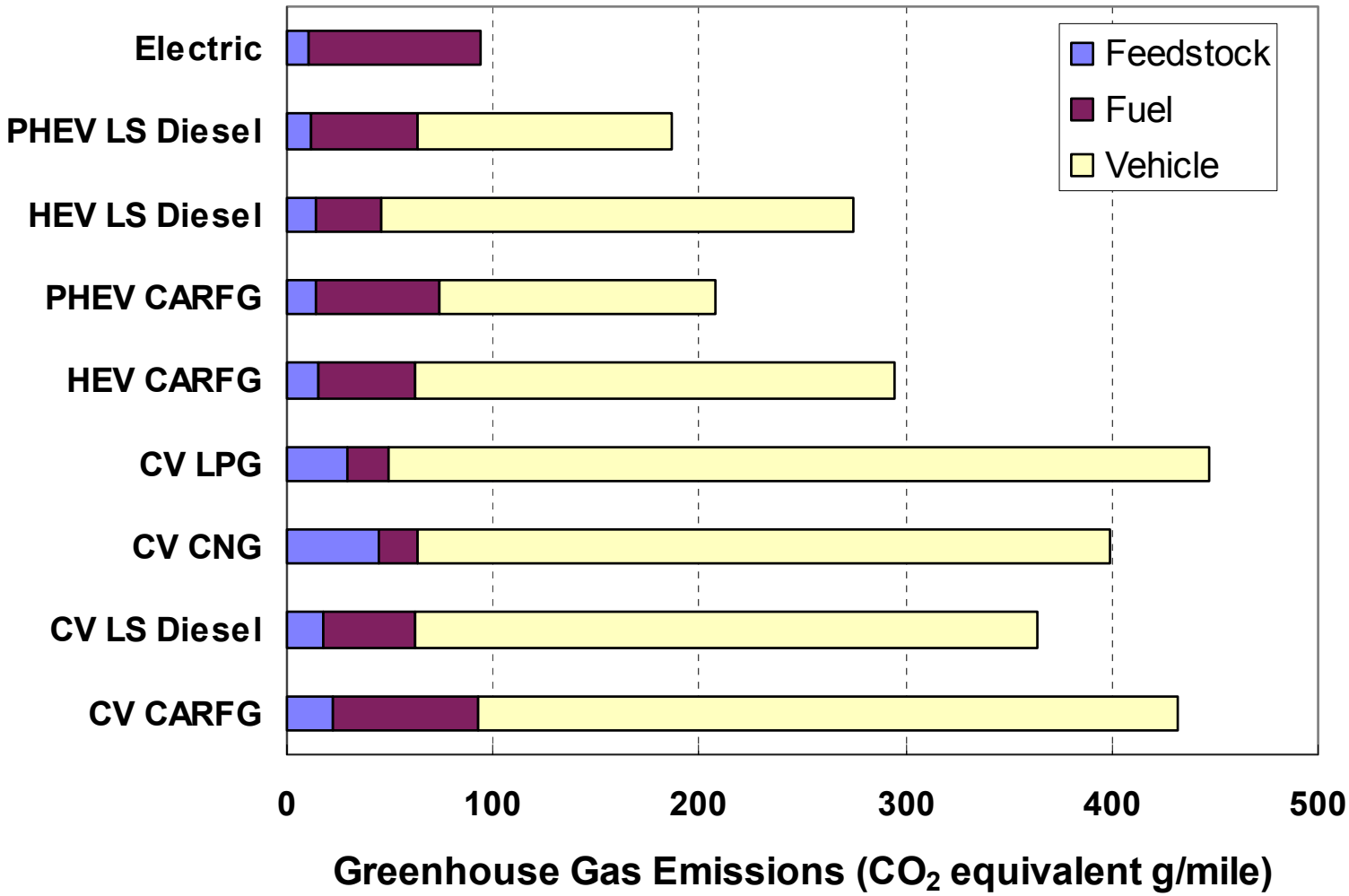
Fuel Economy Comparisons
2010 Assumptions



Fuel Economy Comparisons
2025 Assumptions

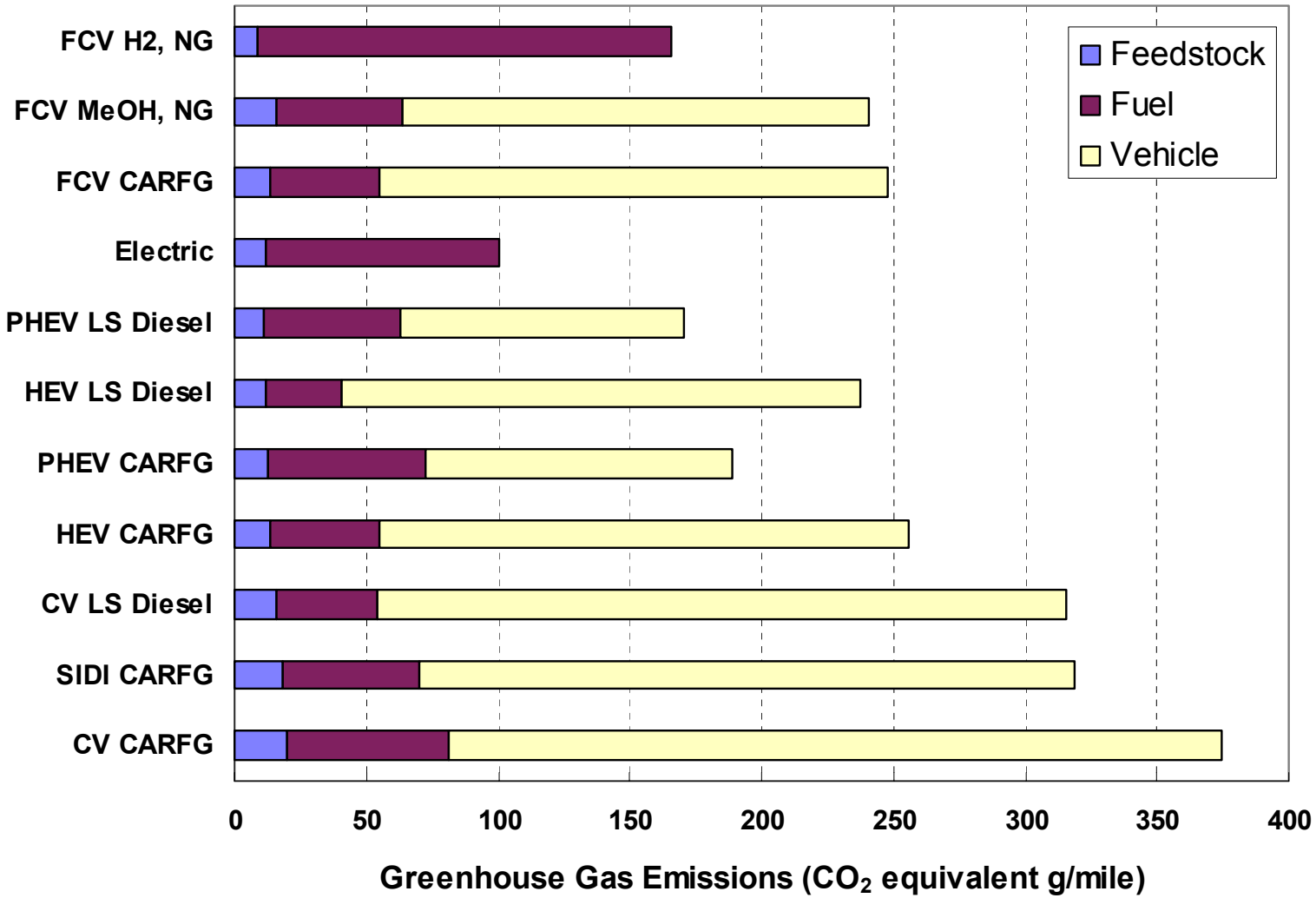


GHG Comparisons
2010 Technologies



GHG Comparisons

2025 Technologies

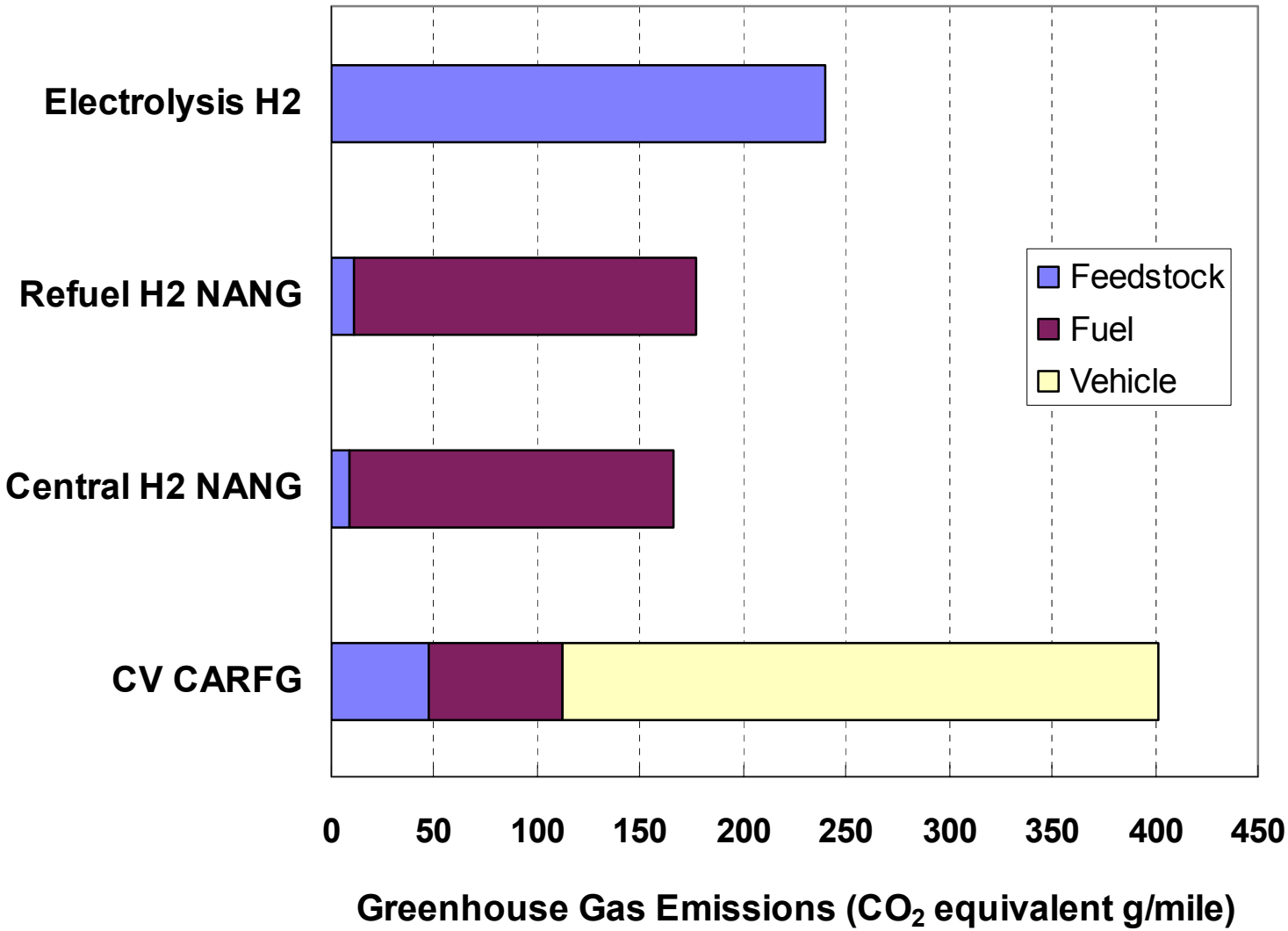


Hydrogen Production Scenarios

- Central Plant
  - North American Natural Gas
- Refueling Station
  - North American Natural Gas
- Electrolysis

GHG Comparisons

Hydrogen Fuel Cells



Renewable Scenarios
Double Counting

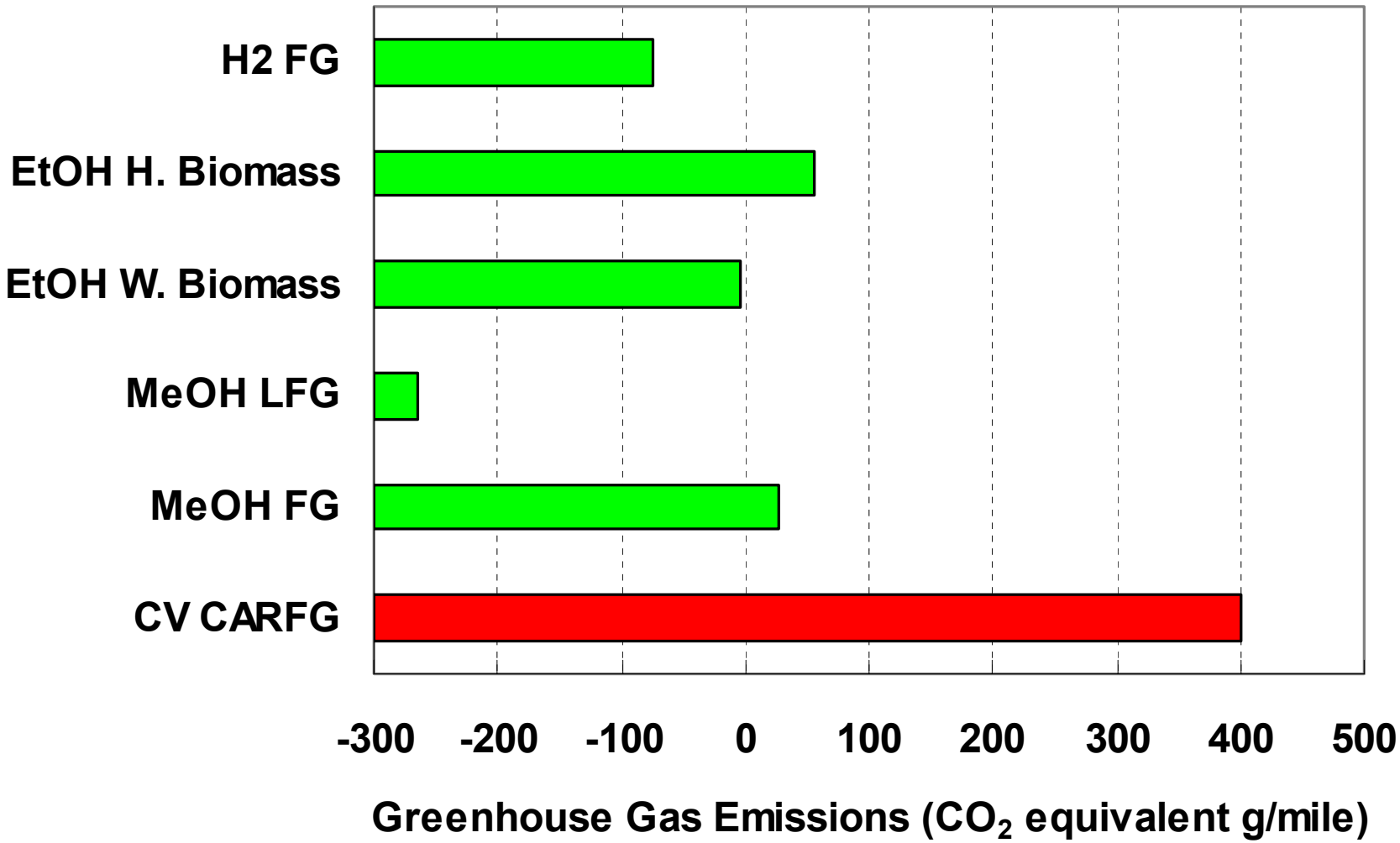
- Flared Gas used for Methanol or Hydrogen
  - Subtract GHGs that would have occurred if flared
- Land Fill Gas used for Methanol
  - Subtract GHGs from LFG entering atmosphere
- Woody or Herbaceous Biomass used for Ethanol
  - Produces Lignin which can be used to produce electricity
  - Net energy produced is greater than that needed to produce the fuel

Renewable Scenarios

- Renewable Fuels and Feedstocks
  - Methanol from Non-North American Flared Gas
  - Methanol from Land Fill Gas
  - Ethanol from Woody Biomass
  - Ethanol from Herbaceous Biomass
  - Hydrogen from Non-North American Flared Gas

GHG Comparisons

Renewable Fuels in Fuel Cells



Conclusions

- Full fuel cycle GHG emissions are affected by feedstock mix, carbon content of the fuel, and vehicle fuel economy
- Near term technologies
  - Gasoline and Diesel HEVs provide over 30% reduction in GHG emissions
  - Plug-in hybrid vehicles provide over 50% reduction in GHG emissions
  - Electric vehicles provide over 75% reduction in GHG emissions

Conclusions

- Fuel cell vehicles operating on gasoline or methanol from natural gas provide equal benefit to diesel HEVs (35%)
- Fuel cell vehicles operating on hydrogen from natural gas provide equal benefit to PHEVs on gasoline or diesel (50%)
- Renewable fuels can provide negative greenhouse gas emissions due to double counting issues

Conclusions

- Ethanol from herbaceous biomass and methanol from flared gas produce very low greenhouse gas emissions
- Ethanol from woody biomass, hydrogen from flared gas and methanol from landfill gas produce negative greenhouse gas emissions
- Both near term and future technologies can significantly reduce greenhouse gas emissions.
- Solutions need to be cost-effective and acceptable to consumers